III. "On the Nature of Electro-capillary Phenomena. I. Their Relation to the Potential Differences between Solutions." By S. W. J. SMITH. Communicated by Professor RÜCKER, Sec.R.S.

"On the Structure and Affinities of Fossil Plants from the Palæozoic Rocks. III. On *Medullosa anglica*, a new Representative of the Cycadofilices." By D. H. SCOTT, M.A., Ph.D., F.R.S., Hon. Keeper of the Jodrell Laboratory, Royal Gardens, Kew. Received December 21, 1898—Read January 26, 1899.

(Abstract.)

The existence of a group of fossil plants, combining in their organisation certain characters of the Ferns and the Cycads, has been recognised, of late years, by several palæobotanists, as, for example, by the late Professor W. C. Williamson, Count Solms-Laubach, Mr. Seward, and the author. The convenient name, Cycadofilices, has recently been proposed by Professor Potonié to designate the group in question, which now includes several, somewhat heterogeneous, genera, among which *Lyginodendron*, *Heterangium*, and *Medullosa* may be mentioned.

Several species of the genus *Medullosa* (founded in 1832 by Cotta) have already been described, from the Permian and Upper Coal-measures of the Continent. They agree in the extraordinarily complex structure of the stem, which, as shown by Zeiller and Solms-Laubach, resembles in the ground plan of its organisation, that of a highly differentiated Fern, of the usual polystelic type, but with the addition of a zone of secondary wood and bast, sometimes reaching an immense thickness, developed around each stele. The mature stem thus acquired a Cycad-like character. The structure, however, has been extremely difficult to interpret owing to the comparative rarity and incomplete character of the specimens hitherto known.

No stem of a *Medullosa* has hitherto been recorded from this country, though specimens of *Myeloxylon*, now known to have been the petioles of *Medullosa*, are frequent in the calcareous nodules of the Lower Coal-measures.

The author has recently had the opportunity of investigating several excellent specimens of a new species of *Medullosa* from the Ganister Beds of Lancashire. These fossils are of special interest on several grounds; they are considerably more ancient than any members of the genus previously described, they are the first English specimens recorded, they are preserved in a more complete and perfect form than

any others at present known, and lastly, the greater simplicity of their structure causes the essential characters of the genus to stand out with greater clearness than in the more complex species. The specimens were discovered by Mr. G. Wild and Mr. J. Lomax, in material from the Hough Hill Colliery, Stalybridge. The sections have been cut, with the greatest skill and success, by Mr. Lomax, and are very numerous, about 100 sections, transverse and longitudinal, having been examined from one specimen alone.

The principal specimens are four in number, in addition to which other fragments have been included in the investigation. The species, which is very distinct from any form previously described, will be known as *Medullosa anglica;* a diagnosis is given below.

The most complete specimen of the stem has a mean diameter of rather more than 7 cm., including the adherent leaf-bases. The others do not appear to have been very different in dimensions.

The large leaf-bases, to judge from the most perfect specimens, almost completely clothed the surface of the stem. They were decurrent, and confluent with the stem for a vertical distance of 13 cm. or more, the diameter of the petiole, where it became free from the stem, being about 3 or 4 cm. The arrangement of the leaves was a spiral one, and in the only case where the phyllotaxis could be determined, the divergence proved to be 2/5.

In two of the specimens the external characters of the fossil are well shown. The outer surface of the long leaf-bases is marked by a conspicuous longitudinal striation, the ribs (which would not have been so prominent during life) representing the fibrous strands of the hypodermal tissue. The habit of the stem, clothed with the long, almost vertical, overlapping leaf-bases, may have been not unlike that of some of the tree-ferns, such as *Alsophila procera*.

The vascular system of the stem consists of three (or locally four) steles, anastomosing and dividing at long intervals. Each stele has an elongated, somewhat irregular, sectional form, and is composed of a central mass of primary wood, surrounded by a zone of secondary wood and phloëm. The primary wood, which is very well preserved, is made up of tracheides and conjunctive parenchyma, with the spiral elements (protoxylem) scattered near its outer margin. The secondary wood consists of radial series of tracheides and medullary rays; the secondary tracheides bear multiseriate bordered pits on their radial walls; most of the primary tracheides are pitted in the same way, but on all sides alike. In the neighbourhood of the protoxylem-groups the tracheides of the primary wood are spiral or scalariform. The phloëm is made up of elongated elements, presumably the sieve-tubes, forming a network, the meshes of which are occupied by the phloëm-rays.

Each stele of *Medullosa anglica* shows the closest agreement in structure with the single stele of a *Heterangium*, so that the stem of this

Medullosa might well be concisely described as a polystelic *Heterangium*.

The course of the leaf-trace bundles was followed very completely in consecutive series of transverse, and in longitudinal, sections. The leaf-traces leave the steles precisely in the same manner as in *Heterangium*. On becoming free the trace is a large concentric bundle, surrounded by its own zone of secondary wood and bast. As it passes obliquely upwards through the cortex, the trace loses its secondary tissues, and undergoes repeated division into a number of smaller bundles, each of which has collateral structure. These collateral strands have in all respects the same arrangement of their elements as the well known bundles of *Myeloxylon*.

The base of the leaf received a large number of bundles, consisting of the ultimate branches derived from the subdivision of several of the original leaf-traces. This distribution of the bundles is peculiar and unlike that in any known plants of Cycadean affinities.

In a few cases accessory vascular strands, of concentric structure, recalling the cortical bundles of a *Cycas*, were found to the outside of the normal stelar system.

The stem formed a well marked zone of internal periderm. In one specimen the whole of the outer cortex, with the leaf-bases, had been exfoliated, so that in this case the periderm formed the external surface.

The leaf-bases and petioles present in all respects, as regards hypoderma, vascular bundles, and gum-canals, the characters of the *Myeloxylon Landriotii* of Renault, which was evidently not a species, but a type of leaf-stalk common to various Medulloseæ. The petioles branched repeatedly, the finest ramifications of the rachis having a diameter of about 1 mm. only, but retaining in essentials the "*Myeloxylon*" structure. The leaf was thus a highly compound one; the structure of the leaflets associated with the rachis agrees well with that of the *Alethopteris* leaflets, figured by M. Renault.

The roots, never previously observed in any species of *Medullosa*, were of triarch structure, with abundant formation of secondary wood and bast, and an early development of internal periderm, by which the primary cortex was thrown off. Developmental stages show that the periderm originated in the pericycle. The roots, which branched freely, were borne on the stem in vertical series, between the bases of the leaves. They were attached to pedicels, through which the vascular tissues of the roots were continuous with those of the stem. The author is indebted to Mr. J. Butterworth and Mr. G. Wild, for specimens which have thrown important light on the connection between root and stem.

The full paper concludes with a short historical *résumé*, and a discussion of affinities.

Medullosa anglica, in the structure of its stem, shows unmistakable

affinities with *Heterangium*, perhaps the most fern-like of the genera grouped under Cycadofilices. The new species is far simpler than any *Medullosa* hitherto described, for the steles are not only few but are uniform, showing no differentiation into a peripheral and a central system. The small central steles, called "Star-rings" in other Medulloseæ, are absent here. In these and other points the species agrees with the genus *Colpoxylon* of Brongniart, but as that genus is doubtfully distinct and its leaves are not known, it is not proposed to unite the English species with it.

In the structure of the petiole and of the leaf generally, *Medullosa anglica* is as highly organised as any of the Medulloseæ, and agrees closely with *M. Leuckarti*, the only other species in which the connection between leaf and stem has been at all satisfactorily proved.

In the structure of the petioles, and of the roots, in the secondary tissues, and in the secretory canals, which occur throughout the plant, there are clear points of agreement with Cycads, though the primary structure of the stem was that of a Fern. The affinities in the latter direction came out more clearly in *Medullosa anglica* than in any of the other species as at present known.

The habit of the leaves, if as appears likely, they were of the *Alethopteris* type, must have been fern-like, but that in itself, as the familiar example of *Stangeria* teaches, is as consistent with Cycadaceous as with Filicinean affinities.

While *Medullosa* thus combines, in a striking manner, the characters of Ferns and Cycads, the author is not disposed to regard it as having lain very near the direct line of descent of the latter group. It is more probable, as Count Solms-Laubach has suggested, that the Medulloseæ represent a divergent branch, which has left no descendants among existing vegetation.

Medullosa anglica, sp. nov.

Stem vertical, clothed by large, spirally arranged decurrent leaf-bases, perhaps cast off in old stems. External surface of leaf-bases longitudinally striate.

Vascular system of stem consisting of a few (usually three) uniform steles, somewhat elongated and lobed as seen in transverse section. Star-rings absent. Interior of each stele wholly occupied by primary wood.

Secondary wood and bast of moderate thickness, developed on all sides of the steles. Tracheides usually with bordered pits.

Leaf-traces concentric on leaving the steles, branching and becoming collateral in traversing the cortex.

Leaf-bases and petioles with the structure of *Myeloxylon Landriotii*, Ren.

Leaves highly compound.

Gum-canals abundant in the petioles and leaf-bases, and in the cortex, and around the steles of the stem.

Adventitious roots borne in vertical series, triarch, with secondary wood and bast, and periderm.

Stem with leaf-bases, about 7—8 cm. in mean diameter.

Petioles about 2·5—4 cm. in diameter at base, diminishing to about 1 mm. in the ultimate branches of the rachis.

Leaflets about 3 mm. wide.

Roots reaching 12 mm. in diameter.

Locality: Hough Hill Colliery, Stalybridge, Lancashire.

Horizon: Lower Coal-measures.

Found by Messrs. G. Wild and J. Lomax, 1892–98.

"On the Nature of Electro-capillary Phenomena. I. Their Relation to the Potential Differences between Solutions." By S. W. J. SMITH, M.A., formerly Coutts-Trotter Student of Trinity College, Cambridge; Demonstrator of Physics in the Royal College of Science, London. Communicated by Professor A. W. RÜCKER, Sec. R.S. Received January 5,—Read January 26, 1899.

(Abstract.)

1. The Lippmann-Helmholtz theory of the capillary electrometer contains two assumptions.

2. The first assumption would apply to any electrolytic cell. A deduction from it, which would apply to any cell having a large and a small electrode, is that the variation of the potential difference at the capillary electrode of an electrometer is the same as that of the applied electromotive force.

In order to trace the relation between surface tension and potential difference on the view that this first assumption is correct, it is necessary to eliminate the possible effect of depolarisation upon the form of the electro-capillary curve—*i.e.*, the curve which shows the relation between the surface tension and the applied electromotive force. A direct method of examining the depolarisation current is described and applied. An estimate of the magnitude of the depolarisation effect is given, and the circumstances under which the effect may become appreciable are discussed.

3. The second assumption of the Lippmann-Helmholtz theory, that the electro-capillary phenomena are controlled by a simple variation of the electrostatic surface energy, leads to two conclusions, each of which is beset with difficulties.